

REMARKS

Claims 1-27 and 36-45 are now pending. Claims 1, 16, 22, 36, 37, 42, and 44 are independent claims. Claims 42-45 are added herein.¹ Claims 1-3, 16, 22, 36, and 37 have been amended to even further clarify the claimed subject matter.

Claims 1-8, 22-25 and 36-39 were rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,973,444 (*Xu et al.*) in view of U.S. Patent No. 6,628,053 (*Den et al.*). Claims 1, 9, 10, 13-15, 22, 26, 27, 36, 40 and 41 were rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. Patent No. 5,847,495 (*Yamanobe et al.*) in view of *Xu et al.* and further in view of *Den et al.* Claims 11, 12, and 16-21 were rejected under 35 U.S.C. 103(a) as being unpatentable over *Yamanobe et al.* in view of *Xu et al.*, *Den et al.*, and U.S. Patent No. 5,066,883 (*Yoshioka et al.*).

The rejection of independent Claims 1, 22, 36 and 37 over *Xu et al.* and *Den et al.* will first be addressed.

As amended, independent Claim 1 recites:

1. An electron-emitting device comprising:
 - (A) a fiber comprising carbon as a main ingredient; and
 - (B) a layer made of a metal-oxide semiconductor, wherein metal-oxide of the metal-oxide semiconductor is selected from the group consisting of titanium oxide, zirconium oxide, and niobium oxide,

¹/ Support for the added claims is provided in the specification as originally filed. For example, regarding Claim 42, page 27, line 25 through page 28, line 15 refers to an oxide of Al as an insulator. As described therein, tunneling would be necessary for supplying an electron to a fiber in a case where an insulator is employed. Accordingly, tunneling would not be necessary for supplying the electron to the fiber in the case where a semiconductor is employed.

See also, e.g., page 28, lines 5-7 regarding support for Claim 44.

wherein the fiber is electrically connected with the layer and the fiber partially contains a catalyst.

As pointed out in the Request For Reconsideration filed on March 17, 2005, *Xu et al.* relates to carbon fiber-based field emission devices and discloses that carbon fiber emitters for field emission devices are catalytically grown onto a selected area of a device surface. An insulating layer, such as silica or alumina, is used as a catalyst support material (see column 7, lines 52-58). *Xu et al.* also discloses that fibers can contain portions of the catalyst; for example, a fiber may contain at least one transition metal or a compound or alloy thereof. Additionally, *Xu et al.* discloses that the transition metal may be Fe, Co, Ni, Cr, Mn, Mo, W, Re, Ru, Os, Rh, Ir, Pd, Pt, Zn, or Cu (see col. 9, lines 25-39).

Page 2 of the Office Action concedes that "Xu does not appear to specify the use of Ti as the component of the oxide semiconductor growth surface...."

Nonetheless, the Office Action then asserts:

"Den in the same field of endeavor discloses the use of Titanium and Titanium Oxide as a growth structure for a carbon nanotubes[, and] discloses the use of a titanium conductor (21) and titanium oxide (35) formed through oxidation on the titanium conductor. (See figure 6A). The titanium oxide is stated as a conductor however its width and method of formation allow it to be partially conductive. (Column 8 lines 5-33). . . . Thus, it would have been obvious at the time the invention was made to person having ordinary skills in the art to the use of semiconductor Titanium Oxide as a growth structure for a carbon nanotubes as disclosed by Den into the device as taught by Xu in order to beneficially control the diameter and direction of the carbon nanotubes thus improving the device characteristics such as emitance conformity in the final product."

The foregoing assertions, which rely on the Examiner's apparent belief that *Den et al.*'s titanium oxide corresponds to that recited in Claim 1, also were made in prior Office Action (dated December 17, 2004) as well, and were traversed by Applicant for the reasons set forth from page 3, line 17 to page 4, line 14 of the Remarks section of the Request For Reconsideration filed on March 17, 2005. Those reasons are repeated and incorporated by reference herein. Briefly, it is respectfully submitted that *Den et al.* does not teach or suggest a layer including a *metal-oxide semiconductor*, wherein the metal-oxide is selected from the group consisting of titanium oxide, zirconium oxide, and niobium oxide, as recited in Claim 1 (emphasis added). Indeed, *Den et al.*'s element 35, which the Office Action states is a titanium oxide conductor that is partially conductive, is a non-conductive insulating layer. Nonetheless, to even further emphasize the patentable distinctions of Claim 1 over *Den et al.*, Applicant now offers the following additional comments.

The "Response to Arguments" section appearing at pages 6-7 of the May 5, 2005 Office Action responded to the Request For Reconsideration by stating:

"Regarding applicant's assertion that the layer 35 of figure 6A in Den ('053) is not semiconductive, the examiner respectfully disagrees. Given the very thin width of the layer and the tunneling properties of the layer, in addition to the operational requirement of charge transfer to the fiber (24) it is the decision of the examiner that the layer in question is in fact semiconductive."

However, Applicant disagrees with the foregoing assertion for the following reasons. Titanium oxide can be of various types, such as an insulating titanium oxide

material or a semiconductor titanium oxide material. In *Den et al.*, the material itself of the layer in question is insulating. In particular, *Den et al.* teaches titanium oxide forming the insulating layer 35 (see column 8, lines 24-26). The titanium oxide of Claim 1, on the other hand, is titanium oxide for a semiconductor layer. Clearly, such a titanium oxide for a semiconductor layer is patentably distinguishable from an insulating titanium oxide such as that taught by *Den et al.* Indeed, the distinction has the technical effects described below.

In *Den et al.*, one end of the carbon nanotube 24 is connected to the insulating layer 35 of the titanium oxide, and the other end is in a floating condition. Accordingly, the carbon nanotube 24 is wholly in a floating condition for potential. To supply electrons to the carbon nanotube 24, it would be necessary, for the sake of argument, to apply a voltage between the carbon nanotube 24 and the conductive surface 21 so that electrons can pass through the insulating layer 35 of the titanium oxide by tunneling. However, because the potential on the carbon nanotube 24 is in a floating condition, that potential characteristically cannot be controlled. Thus, it would be difficult, if not impossible, to determine and provide the appropriate voltage level that would need to be applied to the conductive surface 21 in order to enable tunneling to be performed successfully in a controlled manner, if at all.

Furthermore, even if electrons were to be emitted from the carbon nanotube 24 by supplying electrons to the carbon nanotube 24, when electron emission is attempted again from the carbon nanotube 24 after some electrons already have been emitted, it would be impossible to determine which particular quantity of electrons would have

remained in the carbon nanotube 24 for such further emission. Accordingly, even if the same voltage (as that used to cause the initial emission) is applied to the conductive surface 21 in this attempt to achieve further emission, it would be uncertain, at best, whether or not any electrons would be able to be passed successfully through the insulating layer 35 by tunneling. Consequently, successful, controlled, and repeatable electron emission from the foregoing portion of the *Den et al.* device (i.e., through layer 35) would not be reasonably expected.

In the device of Claim 1, on the other hand, the fiber comprising carbon as a main ingredient is electrically connected with the metal-oxide semiconductor layer which has a metal-oxide selected from the group consisting of titanium oxide, zirconium oxide, and niobium oxide. Since the material of the layer is a semiconductor, the fiber comprising carbon is not in a floating condition, and thus electron emission can be provided by the device of Claim 1 successfully, in a controlled and repeatable manner.

Additionally, according to an aspect of the present invention to which Claim 1 relates, when the layer of oxide semiconductor is used for an underlying layer of the carbon fiber, the adhesiveness between the carbon fiber and the underlying layer is good. Further, as compared with a metal underlying layer, the oxide semiconductor underlying layer has superior stability for characteristics of the underlying layer against heat that is generated during driving of the electron-emitting device in an atmosphere. Those characteristics contribute to suppress any variation or deterioration in characteristics of the electron-emitting device resulting from heat generated when driving the device and the

atmosphere during the driving. The metal-oxide of the semiconductor layer according to the invention is selected from the group consisting of titanium oxide, zirconium oxide and niobium oxide. Those metal oxides are electron conductive oxides. Accordingly, the invention advantageously enables electrons to be supplied to the carbon nanotubes with high stability, for being emitted from the fiber comprising carbon.

In view of the foregoing, it is respectfully submitted that, while *Den et al.* may be well-suited for its intended purpose, the layer made of the metal-oxide semiconductor material of Claim 1 of the present application is clearly patentably distinguishable from the insulating material layer of *Den et al.* Accordingly, even if *Xu et al.* and *Den et al.* were to be combined in the manner proposed in the Office Action (which, in any event, is not admitted as being obvious or technically feasible), the resulting combination would result merely in the insulating layer 35 of *Den et al.* being incorporated into the *Xu et al.* device, and would not teach or suggest at least the above-emphasized features of Claim 1. Accordingly, Claim 1 is believed to be clearly patentable over those references, whether considered separately or in combination. Furthermore, because successful, controlled, and repeatable electron emission from the above-discussed portion of the *Den et al.* device (i.e., through layer 35) would not be reasonably expected, for these reasons as well, it is believed that the Office Action has failed to establish a *prima facie* case of obviousness against Claim 1. MPEP 2143 ("To establish a *prima facie* case of obviousness, . . . there must be a reasonable expectation of success."). Therefore, Claim 1 is believed to be patentable over the foregoing references for this reason as well.

Independent Claims 22, 36, and 37 recite features that are substantially similar in many respects to those of Claim 1 emphasized above, and also are believed to be clearly patentable over *Xu et al.* and *Den et al.*, whether considered separately or in combination, for substantially the same reasons as those set forth above. Accordingly, withdrawal of the rejection of Claims 1, 22, 36, and 37 is respectfully requested.

The rejection of Claims 1, 22, and 36 over *Yamanobe et al.* in view of *Xu et al.* and *Den et al.*, will now be addressed.

The Office Action cites *Yamanobe et al.* for disclosing an electron-emitting device including first and second electrodes, and means for applying voltages thereto. However, it is respectfully submitted that nothing in that reference would teach or suggest the above features of Claims 1, 22, and 36 relating to the semiconductor layer.

Furthermore, for the reasons set forth above, neither *Xu et al.* nor *Den et al.* teaches or suggests those features. Accordingly, Claims 1, 22, and 36 are deemed clearly patentable over *Yamanobe et al.*, *Xu et al.*, and *Den et al.*, whether considered separately or in combination. As such, withdrawal of the rejection of Claims 1, 22, and 36 over those references is respectfully requested.

The rejection of Claim 16 over *Yamanobe et al.* in view of *Xu et al.*, *Den et al.*, and *Yoshioka et al.*, will now be addressed.

Claim 16 recites, in part, a metal-oxide semiconductor layer disposed on a first electrode, wherein a metal-oxide of the metal-oxide semiconductor layer is selected from the group consisting of titanium oxide, zirconium oxide, and niobium oxide.

The Office Action cites *Yamanobe et al.* for disclosing the use of a step portion 21 under the first electrode to raise the electrode higher than the second electrode, and cites *Yoshioka et al.* for disclosing the use of directly etching the substrate in order to create a step portion and raise the first electrode. However, it is respectfully submitted that nothing in either reference would teach or suggest the above-recited features of Claim 16.

Furthermore, for the reasons set forth above, neither *Xu et al.* nor *Den et al.* teaches or suggests those features of Claim 16. Accordingly, Claim 16 is deemed clearly patentable over *Yamanobe et al.*, *Xu et al.*, *Den et al.*, and *Yoshioka et al.*, whether considered separately or in combination. As such, withdrawal of the rejection of Claim 16 is respectfully requested.

Added independent Claims 42 and 44 each recite features that are similar in many relevant respect to those of the independent claims discussed above, and also are believed to be patentable over each of the respective combinations of references postulated in the Office Action, because nothing in those references, whether considered separately or in combination, would teach or suggest those features.²

The other claims in this application are each dependent from one or another of the independent claims discussed above and are therefore believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of

^{2/} In addition, nothing in *Den et al.* would teach or suggest that fibers are electrically connected with the semiconductor layer without a tunnel junction, as recited in Claim 42, and that titanium oxide, zirconium oxide, and niobium oxide are made into a semiconductor due to an oxygen missing crystal structure (see, e.g., Claim 44.)

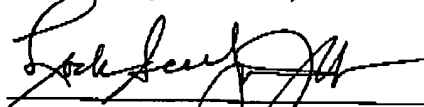
the invention, however, the individual consideration or reconsideration, as the case may be, of the patentability of each on its own merits is respectfully requested.

This Amendment After Final Rejection is believed clearly to place this application in condition for allowance and its entry is therefore believed proper under 37 C.F.R. § 1.116. In any event, however, entry of this Amendment After Final Rejection, as an earnest effort to advance prosecution and reduce the number of issues, is respectfully requested. Should the Examiner believe that issues remain outstanding, he is respectfully requested to contact Applicant's undersigned attorney in an effort to resolve such issues and advance the case to issue.

Favorable consideration of the added claims and early passage to issue of this case are requested.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100 or by facsimile at (212) 218-2200. All correspondence should continue to be directed to our address given below.

Respectfully submitted,



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